

FLEXIBLE WIND ABATEMENT SYSTEM

1 This application is a continuation-in-part of S.N.

- 2 09/565,211 which is a continuation of S.N. 09/270,249, now U.S.
- 3 Pat. No. 6,176,050 Bl, which is a continuation-in-part of S.N.
- 4 08/861,209, now abandoned. The content of all the prior
- 5 applications and the prior art cited in each of the
- 6 applications is incorporated herein by reference.

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Technical Field

9 This invention relates to the protection of property

10 against high winds and, in particular, to a flexible protective

11 barrier device for securing property from damage from the wind

12 itself and from the impact of foreign objects carried by wind

as occasioned by hurricanes, tornadoes and the like.

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Background Art

16 As is known by one skilled in the art of protecting

17 buildings and the like from damage caused by missile-like

18 objects that are occasioned by the heavy winds of hurricanes or

tornadoes, there are commercially available variations of

20 hurricane protective devices, often called shutters, that

21 fasten immediately over the frangible area to be protected.

22 These devices are typically expensive to purchase, cumbersome,

made from stiff, heavy material such as steel and aircraft 1 or occasionally plastic 2 guality aluminum alloy Many need to be manually connected and then 3 removed and stored at each threat of inclement weather. Many require unsightly and difficult-to-mount reinforcing bars at 5 multiple locations. Further, these known shutters are usually 6 opaque, preventing light from entering a shuttered area and 7 preventing an inhabitant from seeing out. Likewise, it is 8 desirable that police be able to see into buildings to check 9 for inhabitants and to prevent looting which can be a problem 10 in such circumstances. Missiles, even small not potentially 11 damaging missiles, striking these heretofore known shutters 12 create a loud, often frightening bang that is disturbing to 13

Standardized testing requiring these protective devices 15 16 to meet certain standards of strength and integrity has been introduced for various utilizations and locales. In order to 17 18 qualify for use where said testing requirements apply, the strength and integrity characteristics of these protective 19 devices must be predictable and must be sufficient to meet said 20 standards. Additionally, and as is obvious to one skilled in 21 . 22 the art, it is beneficial to qualify for said standards even in situations in which standards do not apply. As a result of 23 24 said standards, many undesirable aspects of the heretofore

inhabitants being protected.

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1 known shutters have been acerbated. They have become more

2 cumbersome, more bulky, heavier, more expensive, more difficult

3 to store, and remain generally opaque and noisy when impacted.

4 To incorporate sufficient strength to meet said requirements,

5 weight and bulk become a problem over six feet in span. The

6 useable span (usually height) of the heretofore known shutters

7 that meet said standards may be limited to eight feet or less.

8 This makes protecting large windows, for example, or groupings

of windows, with the heretofore known devices cumbersome,

10 expensive and impractical. Devices that are intended to be

11 deployed in a roll down manner either manually, automatically,

12 or simply by motor drive, have been difficult to strengthen

sufficiently to pass the test requirements and require

14 unsightly reinforcing bars every few feet.

Prior to the introduction of said standards, an ordinary consumer had very little useful knowledge of the strength and integrity of said shutters. It is believed shutters of the pre-standard era were very weak such that all would fail the present standardized testing. It should be understood that the standards are not intended to provide a shutter that will protect in all situations. As the hurricane conditions can be very violent and destructive, the standards are not intended to require strength and integrity sufficient to protect in all circumstances. The standards simply provide a benchmark as to

- 1 strength and integrity. Said strength and integrity of the
- 2 shutters can now be measured.
- 3 There are a sundry of patents that teach the utilization
- 4 of knitted or woven fabric such as netting, tarpaulins, drop
- 5 cloths, blankets, sheets wrapping and the like for anchoring
- 6 down recreational vehicles, nurseries, loose soil and the like.
- 7 But none of these are intended for, nor are capable of
- 8 withstanding the forces of the missile-like objects that are
- 9 carried by the wind in hurricanes. Examples where fabric or
- 10 netting material that encapsulates the unit to be protected as
- 11 by covering the entire unit and fastening the ends of the
- 12 fabric to the ground are disclosed in the following patents.
- 13 United States Patent Nos. 3,862,876 issued to Graves, 4,283,888
- 14 and 4,397,122 issued to Cros, 4,858,395 issued to McQuirk,
- 15 3,949,527 issued to Double et al., 3,805,816 issued to Nolte,
- 16 5,522,184 issued to Oviedo-Reyes, 4,590,714 issued to Walker
- 17 and 5,347,768 issued to Pineda. The 5,522,184 patent for
- 18 example, provides a netting that fits flush over the roof of a
- 19 building and uses a complicated anchoring system to tie down
- 20 the netting to strengthen the building structure against
- 21 hurricanes and wind storms.
- 22 Certain types of flexible material that are capable of
- 23 withstanding high wind loading or impact loads without
- 24 bursting, can be disposed in front of the building or other

structures intended to be protected, and anchored on opposing 1 edges, to form a curtain sufficiently spaced from the frangible 2 3 area to contain the impact of foreign objects hurled by the high winds. For example, in a building the top edge of the 4 fabric may be anchored to the eave of the roof and the bottom 5 of the fabric may be attached to anchors imbedded in the ground 6 or cement, so as to present a curtain adequately spaced out 7 from and in front of the structure of the building to be 8 protected. Not only does this afford frontal protection but, 9 properly located and attached, it also serves to tie down the 10 roof and protect it from blowing off. The winds that would 11 ordinarily blow off the roof exert a force on the fabric which, 12 in turn, exerts a downward force on the roof to act against the 13 lifting forces tending to lift the roof. 14 15

Thus, what is lacking in the art is a flexible protective barrier constructed from a mesh material that can be easily stored and deployed for protecting the frangible portion of a structure from objects carried by the wind.

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Summary of the Invention

This invention contemplates the use of a flexible barrier, 2 preferably a reasonably transparent, woven synthetic textile 3 that is able to satisfy stringent testing requirements. 4 Knitted or extruded material can be an alternative if the 5 material itself meets the criteria described later herein. The 6 7 use of this invention allows very large areas with spans of greater than 25 feet to be covered with ease. Thus most window 8 groupings, even several stories of a building, could be readily 9 This invention is light in weight, easy to use, protected. 10 does not require reinforcing bars, can be constructed in 11 varying degrees of transparency, can be weather tight, is 12 13 economical, and is capable of dissipating far greater forces without damage than the heretofore known stiff devices. 14 Missiles striking this barrier make very little sound. 15 invention is suitable to be configured with the necessary motor 16 and supportive devices for automatic deployment. 17 Heretofore known devices have internal stiffness and 18 19 rigidity that resists deflection, or bending. It is this

stiffness that stops the missile short of the frangible surface
being protected. This invention does not have rigidity but
rather is very flexible, which give several positive features
including allowing for ease of storage as by rolling or
folding. The flexible barrier of the invention is placed a

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installation.

distance out from the surface to be protected. An impacting 1 missile stretches the barrier until it decelerates to a stop or 2 3 is deflected. The barrier material has a predetermined tensile strength and stretch that makes suitable for this 4 it Said known strength and stretch, together with application. 5 the speed, weight and size of the impacting missile, all of 6 which are given in test requirements, permit design calculation 7 to ascertain barrier deflection at impact. This deflection is 8 9 a determinate of the minimum distance that this barrier is to 10 be spaced out from the frangible area to be protected. Other determinates which may be included are additional deflection 11

from wind pressure and from slack from an

The barrier of this invention is mounted farther away from the surface to be protected than the prior art structures, thereby providing room for a longer deceleration of impacting flying debris (missiles). Thus greater energy from a missile can be safely dissipated than is possible with the prior art structures, and the energy which can be safely dissipated is calculable.

The distance which the barrier is spaced out from the frangible surface need not be great and is quite workable with existing structures. Even though the distance is not great, said distance does allow a significantly increased distance and

1 time of deceleration such that the barrier will stop far

2 stronger impacts than with the heretofore known rigid devices.

3 In simple terms, the missile is slowed to a stop by elasticity

4 as the barrier stretches. The greater the impact, the greater

5 the stretch. Thus the building is not subjected to an abrupt

6 harsh blow as the impact on the shutter is transferred to the

7 building. The energy transfer is much gentler and less

8 destructive than with the rigid devices.

It will be obvious to one skilled in this art that this 9 device goes beyond merely hanging a curtain in front of a 10 structure and hoping wind born missiles will be stopped. 11 invention provides a method of calculating the minimum spacing 12 of said barrier from the frangible surface and provides 13 understanding as to the strength and integrity of said barrier. 14 This invention contemplates using a screen-like fabric with 15 interstices that permit the light to pass through and that is 16 reasonably transparent. Of course, if interstices are utilized 17 in the fabric makeup, the size of the interstices must consider 18 the size of the missiles such that the missiles do not pass 19 therethrough. If transparency is not desirable, the fabric can 20 be made sufficiently dense to minimize or eliminate the 21 22 interstices. To assure a long life, the material of the fabric preferably would be resistant to the ultra violet radiation, 23 and to biological and chemical degradation such as are 24

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1 ordinarily found outdoors. This invention contemplates either

2 coating the material or utilizing material with inherent

3 resistance to withstand these elements. A synthetic material

4 such as polypropylene has been found to be acceptable. An

5 example of a coated material is vinyl coated polyester.

6 Materials intended to be used outdoors in trampolines, for

7. example, are likely candidates for use in this invention.

8 Black colored polypropylene is most resistant to degradation

from ultra violet radiation. Other colors and vinyl coated

10 polyester are sufficiently resistant, particularly if the

11 barrier is not intended to be stored in direct sunlight when

12 not in use.

The preferred embodiment allows air passage through it, albeit at substantially reduced rate. An upwind pressure of 1" of mercury, which roughly translates into a 100 miles per hour (mph) wind, forces air through at 250 cubic feet per minute (cfm) or approximately 3 mph. The amount of air passage depends on the interstice size. If a weather tight and transparent barrier is desired, the polypropylene material may be laminated with a flexible clear plastic skin.

It is of importance that the material affords sufficient impact protection to meet the regulatory agencies' requirements in order for this to be a viable alternative to other hurricane protective mechanisms. While stiff structures, such as panels

of metal, are easily tested for impact requirement and have 1 certain defined standards, fabrics on the other hand, are 2 flexible and react differently from stiff structures. 3 the testing thereof is not as easily quantified as the stiffer 4 However, certain imperial relationships exist so 5 that correlation can be made to compare the two mediums. 6 Typically, the current impact test of certain locales requires 7 a wood 2x4 stud be shot at the barrier exerting a total force 8 of approximately 230 pounds, or 61.3 pounds per square inch (psi), over its frontal (impacting) surface. This impact and 10 resultant force relate to the Mullen Burst test commonly used 11 12 by manufacturers to measure the bursting strength of their fabrics. Thus the impact test heretofore used on rigid devices 13 will work equally well on this flexible device. 14 15 The preferred embodiment of this invention would use a 16 textile of the type typically used in trampolines which would burst at 675 psi or a total of 2,531.25 pounds over the same 17 3.75 square inch frontal surface of the nominal 2x4 test 18 missile and would stretch 21% immediately prior to failure. . 19 20 The strength and stretch characteristics of the material are 21 The strength of this fabric is more than eleven (11) times the 230 pounds of strength required to withstand the 22. above-described 2x4 missile test as presently required by said 23 regulatory agencies. Stronger fabrics are available. Others 24

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1 are available in various strengths, colors and patterns. The

2 maximum deflection can readily be calculated and hence the

3 distance that the fabric must be spaced from the surface being

4 protected can be easily ascertained.

As one skilled in this art will appreciate, the reason for the utilization of stiff materials for protection against the high winds and missile-like objects propelled thereby is because heretofore known barriers are mounted close to the frangible object being protected. Obviously, if the protective material is mounted close to the protected surface, it must necessarily be stiff in order to stop the missile short of the protected frangible surface. In such a situation, impacting missiles are required to come to an abrupt stop. Such abrupt stop of the missile on impact with the surface of the protecting structure is less desirable because the rapid energy dissipation has the propensity to cause damage not only to the protective device, but to the structure being protected as well. An extended controlled deceleration is not available if the barrier is mounted close to the frangible surface.

The use of flexible fabric distanced out from the frangible area as a protective barrier allows extended deceleration. When the strength and stretch properties of the fabric are known and allowed for, the extended deceleration becomes controlled. By mounting the protective barrier some

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distance from the frangible surface, a distance that is 1 2 calculable, the missile can be decelerated to a stop prior to contacting the frangible surface. In other words, in any 3 situation where the missile must stop prior to impacting the 4 5 frangible surface being protected, it is desirable 6 decelerate the missile through an extended controlled

deceleration. This invention does precisely that.

An extended deceleration has much less propensity to cause damage than an abrupt deceleration. Since the use of a flexible material as a protective barrier affords an extended deceleration, very strong impacts can be withstood. It is contemplated that this invention, using the proper material and the proper assembly, will be sufficient to meet all foreseeable impact test requirements and regulations for wind and debris protection. Such requirements and regulation would include more severe tests being contemplated for specialized, high protection, shelters.

Thus, an object of this invention is to provide a barrier made from fabric to protect the frangible portions of a building and the like. A feature of this invention is spacing the barrier out from and in front of the frangible area to be protected by attaching two opposing edges to anchors located so as to position the barrier as described. Another feature is the formula for calculating minimum spacing.

For example, one edge of the fabric can be anchored to the 1 overhang of the roof or other high structure and the opposite 2 edge of the span to the ground or low structure to provide a 3 barrier spaced from and in front of the object to be protected. 4 The lower anchors can be attached to the ground by imbedding 5 6 in cement or other ground attachment such as tie downs or stakes and the like and providing grommets, rings or other 7 attachments in the fabric to accept a clamp, cable, rope, and 8 9 the like. The barrier is sufficiently spaced from the structure being protected in order to absorb and dissipate the 10 energy from impact prior to the impacting object reaching the 11 12 structure. The deceleration of the impacting object is extended in comparison to a stiff barrier. 13 barrier of this invention 14 The curtain-like is 15 characterized as a reasonably transparent barrier with strength 16 and simplicity that is unattainable with the heretofore known 17 Wind loading on windows is eliminated. Impact by barriers. a missile does not cause a large bang, and is not disturbing. 18 Frame harmonics are reduced or eliminated, such harmonics are 19 known to cause catastrophic failure of structures. 20 The 21 envelope of the structure is secured even if a window has 22 Wind lift is spoiled to prevent uplifting of roofs. It is easy to install, requires low maintenance and has 23

low acquisition cost. There is much flexibility with storage.

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It can either be left in place or rolled much as a shade, orslid out of the way much as a curtain, so as not to obstruct

3 the translucent of the window or interfere with the aesthetics

4 of the building. It can also be fully removed and stored out

5 of the way, or swung up to form a canopy when not in use as a

6 protective barrier. It is preferable but not essential, that

7 the material selected to be used in the netting fabric of this

8 invention be inherently resistant to elements encountered in

the outdoors or can be coated with coatings that afford

10 resistance to these elements. Another feature of this

invention is that it is capable of providing the dual function

12 of protection against flying missiles as well as providing

anchoring capabilities, such as tying down the roof of the

building or structure being protected to prevent it from being

15 lifted off.

16 Another feature of this invention is that it can be

17 reasonably transparent if desired without adversely affecting

18 the integrity of the barrier.

19 Another objective of this invention is that wind loading

20 on windows is eliminated wherein the wind load is transferred

21 to the surrounding support structure.

22 Still another objective of this invention is to reduce or

23 eliminate structure harmonics caused by high winds and the

24 resulting structure failure caused by such vibrations.

1	Yet	still	another	objective	of	this	invention	is	to
2	maintain	the env	relope of	the struct	ure	to pre	event uplift	ing	of
2	the roof	gunnort	- by wind	entering o	of t	he str	ucture		

Another objective of this invention is to provide a means to spoil wind lift that may be otherwise cause a roof structure to detach from a structure.

Another feature of this invention is that missile impact
is reasonably quiet and not a loud frightening bang as with
heretofore known rigid devices.

Other objectives and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawings wherein are set forth, by way of illustration and example, certain embodiments of this invention. The drawings constitute a part of this specification and include exemplary embodiments of the present invention and illustrate various objects and features thereof.

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1 Brief Description of Drawings

- 2 Fig 1. is a partial view in perspective and schematic
- 3 illustrating this invention in the deployed position and
- 4 attached a building;
- 5 Fig. 2 is a partial view in section illustrating mechanism .
- 6 for tying down the protective barrier;
- 7 Fig. 3 is a perspective of the barrier fabric;.
- 8 Fig. 4 is a detailed showing of alternative mechanism for
- 9 attaching the barrier to a structure;
- 10 Fig. 5 is a partial view illustrating a panel edge
- 11 closing;
- Fig. 6 is a partial section of a tie-down;
- Fig. 7 is a partial section of another tie-down along line
- 14 7-7 of Fig. 8;
- Fig. 8 is a perspective, partly in section, of the tie-
- 16 down of Fig. 7;
- 17 Fig. 9 is a perspective, partly in section, of a ground
- 18 anchor and connection to the barrier;
- 19 Fig. 10 is a perspective of an edge closure; and
- Fig. 11 is a perspective of another edge closure.
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Detailed Description of the Preferred Embodiment

- The invention does not derive its strength from stiffness 2 or rigidity but rather from its bursting strength and stretch, 3 with the latter acting like a spring to gradually decelerate 4 any impacting missile. To be able to calculate the minimum 5 distance that the barrier must be placed out from the area to 6 be protected, the frontal area, weight and speed of the test 7 missile must also be known. Wind speed may become a 8 significant factor in large spans. 9 There are many additional desirable characteristics of 10 this invention such as transparency, resistance to weathering, 11 light weight, ease of installation, deployment and storage, 12 economy. 13 While this invention is shown in its preferred embodiment 14 as being utilized to protect the windows and overhang roof of 15 a structure, it is to be understood that this item has utility 16 17 for other items requiring protection and is applicable to other types of structures. Where appropriate, the barrier can be
- deployed horizontally or at any angle as well as the vertical 19
- as shown in Fig. 1. 20
- Reference is now made to Figs. 1 which shows a building 21
- structure 10 intended to be protected from the onslaught of 22
- winds and debris typically occasioned during a hurricane. Fig. 23
- 1 shows barrier 61 deployed to completely envelop the building 24

structure 10. In this embodiment, the roof 68 is completely 1 covered by barrier panel 61 which has integral side panels 62 .2 and 64 which extend from the roof to the ground. 3 Α shorter end panel 62 protects the end of the building and 4 longer front panel 64 covers the front of the building. 5 course, these panels are duplicated at the other end and rear 6 As shown, the side panels are sloped 7 of the building. outwardly from the roof toward the ground. This orientation 8 creates a gap between the panels at the corners of the 9 building. A joining panel 63, shown in Fig. 1, connects the 10 adjacent side panels and provides a continuous barrier 11 surrounding the structure. A joining panel is in place at all 12 four corners of the building. 13 2 illustrates an anchoring system 65 that provides 14 a tie-down for the barrier side panels and joining panels which 15

Fig. 2 illustrates an anchoring system 65 that provides a tie-down for the barrier side panels and joining panels which provides a holding power at least equal to the burst strength of the barrier material. As shown, the side panel 62 has a continuous folded reinforced hem 69 attached to an anchoring strap 66. The strap 66 is passed through the eye of a ground anchor 72. The ground anchor 72 is similar to the ground anchor 110, shown in Fig. 9. The free end of the strap 66 is threaded through a friction buckle 67 which has a locking

- 1 roller 82. As tension is applied to the strap 66, the friction
- 2 grip of roller 82 increases.
- 3 The upper margin of the side panels may have a batten 70,
- 4 as shown in Fig. 4. The upper edge of the side panels may be
- 5 attached to the roof beyond the batten (not shown). The batten
- 6 70 may be attached to the building over the eave 71 or to the
- 7 barrier. The batten 70 serves the dual purpose of protecting
- 8 the edge of the roof and providing a large diameter, smooth
- 9 surface about which the barrier turns approximately 90 degrees.
- 10 The batten may be made of any material which will not deform
- 11 under the compression and shear created by the barrier under a
- 12 wind load.
- A suitable material for the barrier 61 is polypropylene
- 14 formed in a monofilament and woven into a geotextile (style
- 15 20458) manufactured by Synthetic Industries of Gainesville,
- 16 Georgia. The fabric is woven in a basket (plain) weave as
- 17 shown in Fig. 3 where the fill 11 and warp 13 threads
- 18 alternately cross over and under adjacent fills and warps. In
- 19 the preferred embodiment the interstices are substantially
- 20 equal to 0.6 millimeters which approximates the interstices of
- 21 commercially available residential window screening.
- The barrier fabric may be coated or have inherent
- 23 resistence to withstand the elements. A synthetic material
- 24 such as polypropylene has been found to be acceptable. Also,

clear plastic skin.

1 a vinyl coated polyester may be used in the barrier. Materials

2 intended to be used outdoors in trampolines, for example, are

3 likely candidates for the barrier material. Such materials

4 have a burst or failure limit of 675 pounds per square inch

5 (psi). Black colored polypropylene is most resistant to

6 degradation from ultraviolet (UV) radiation.

The preferred embodiment has air permeability albeit at 7 substantially reduced rates. An upwind pressure of 1 inch of 8 9 Mercury (Hg.), which is roughly equivalent to 100 miles per wind speed, forces air through the material 10 approximately 250 cubic feet per minute (cfm) or approximately 11 3 mph. The amount of air permeability depends on interstice 12 size. If a weather tight and transparent curtain is desired, 13 the polypropylene material may be laminated with a flexible 14

16 The selection of interstice size and configuration is 17 dependent on the amount of transparency and air passage desired 18 and the limitation that the maximum size must be sufficiently 19 small to prevent objects that are potentially damaging on 20 impact from passing therethrough. The above mentioned 21 regulations set in place by Dade County, Florida have 22 determined that the smallest diameter missile (wind blown 23 debris) with which they are concerned is 3/8 inch in diameter. 24 Therefore to satisfy the Dade County Regulations

- 1 interstices must be small enough to prevent 3/8 inch diameter
- 2 missiles from passing therethrough. Other regulations may set
- 3 other minimum missile diameter sizes. The interstice size
- 4 would similarly relate thereto if the barrier were intended to
- 5 satisfy said other regulations.
- 6 The endurance, physical, hydraulic and mechanical
- 7 properties of the textile are recorded and available from the
- 8 manufacturer, Synthetic Industries. It is important to this
- 9 invention that whatever type of material is utilized, the
- 10 fabric made up from this material must exhibit sufficient
- impact strength for resisting the test impact loads at least to
- 12 the values dictated by the various industrial, insurance and
- 13 government regulating agencies. This particular fabric has
- 14 been shown to be able to withstand forces at over 11 times the
- 15 test load required by the regulating agency presently in the
- 16 forefront of standard setting.
- 17 The material selected must meet certain strength criteria.
- 18 These criteria, together with the size of span covered by the
- 19 barrier, constitute the basis for calculating the spacing of
- 20 the barrier from the object being protected. Said spacing is
- 21 calculated as follows:
- 1) The fabric must be sufficiently strong that the impact
- 23 force it is required to withstand is less than the failure
- 24 force (Mullen Burst).

- 2) The impact (test) force is then divided by the force required to cause failure (Mullen Burst). This quotient is then multiplied by the known stretch at failure to obtain the stretch factor. The woven polypropylene synthetic fabrics of the type used in the preferred embodiment stretch 20 22% just prior to failure, depending on manufacturing technique. This stretch information is available from the manufacturer.
 - 3) The actual stretch measurement is then calculated and in conjunction with the span of the barrier used to ascertain the maximum deflection. This maximum deflection is the minimum distance the barrier should be spaced from the frangible object being protected.

EXAMPLE:

The preferred embodiment is used as an example to demonstrate this formula. The preferred embodiment is a polypropylene, woven monofilament geotextile. The individual filaments are woven into a basket weave network and calendered so that the filaments retain dimensional stability relative to each other. This geotextile is resistant to ultra violet degradation and to biological and chemical environments normally found in soils. This fabric is often used as the mat for outdoor trampolines and is intended to be very resistant to weathering. The fabric is known to stretch a maximum of 21% prior to

- failure and requires a force of 675 psi to fail.
- 2 1. The present test that was originally legislated by
- 3 Dade County Florida and may become the standard in the
- 4 industry, requires the barrier to withstand a force of
- only 61.3 psi. Consequently the fabric meets and
- 6 exceeds the first requirement of strength.
- 7 1. The stretch factor calculation is (test load ,
- 8 maximum load x %stretch at maximum load = stretch
- 9 factor) $61.3 / 675 \times 21 = 1.9\%$. This becomes a
- 10 constant factor insofar as this fabric and the Dade
- 11 test remain involved. The calculation will change
- if any one or more of the strength, energy or
- stretch characteristics of the test or fabric are
- 14 modified. Likewise, it is known that stretch varies
- 15 directly with force up to the maximum at failure. To
- 16 calculate the actual stretch, the calculation is
- stretch factor x height = actual stretch. Therefore
- if the distance between the two fastened sides is
- 19 eight feet (96 inches), the stretch measurement will
- 20 be $96 \times 1.9\% = 1.83$ ".
- 21 2. To calculate the deflection, right triangles are
- used such that the hypothenuse is % of the sum of
- 23 the height plus stretch (97.83/2 = 48.92"). The
- known side is $\frac{1}{2}$ of the height (96/2 = 48"). Thus

the deflection = the square root of the difference between the square of the hypothenuse less the square of the known side. This result is 9.4" which is the maximum deflection on impact by test missile.

3. Thus to meet the prescribed standard the barrier must be mounted so as to be spaced at least 9.4 inches from the surface to be protected if an eight (8) foot span is to be used. A longer span will require wider spacing, a shorter will require less. The table shown below reflects this spacing for various sample distances of span with this preferred fabric.

Table demonstrating relationship between Span and Maximum Deflection in the Preferred Embodiment as Described Above.

Не	ight	Deflection			
8	feet	9.4 inches			
10	"	11.8 "			
12	"	14.1 "			
14	w	16.5 "			
16	"	18.8 "			
18	"	21.2 "			
20	"	23.5 "			
22	W	25.9 "			
24	11	28.2 "			
30	W	35.2 "			
40	"	47.0 "			

The aforementioned formula is sufficient to provide 2 spacing to meet the test standards. As the spacing is intended 3 to be minimum, and although the barrier is intended to meet or 4 exceed test standards as opposed to warranting protection in 5 actual situations which are difficult to predict, this 6 invention can include an additional factor in the spacing to 7 allow for maximum wind pressure. Arbitrarily assuming a 115 8 mph wind at 90 degrees to the barrier and assuming the barrier 9 10 has been made weather tight with no air flow through the barrier to somewhat relieve pressure, and assuming the barrier 11 is installed at sea level where air is densest, the additional 12 pressure on the barrier will be .237 pounds per linear inch of 13 This additional pressure can be resolved into a vector 14 and added directly to the test force of 61.3 pounds. 15 8 foot barrier will have an additional (.237 x 96=) 16 22.75 pounds added for a total of 84.05 pounds. A 40 foot barrier 17 18 will have $(.237 \times 480 =) 113.76$ pounds added for a total of This number should be substituted into the 19 175.06 pounds. above formula to give a more accurate calculation of minimum 20 21 spacing. For example: an 8 foot barrier could deflect 10.9" when

For example: an 8 foot barrier could deflect 10.9" when allowing for a 115 mph wind factor rather than 9.7" if the wind

- 1 was not factored in. The deflection of a 40 foot barrier
- becomes 80.28" (6.69') rather than 47" (3.9').
- 3 Obviously, once the minimum space between the barrier and
- 4 the structure being protected is established, the fabric must
- 5 be anchored in a suitable manner so as to absorb the loads
- 6 without being torn from its support. In some installations,
- 7 the building may have adjacent areas, such as a patio or pool
- 8 deck or drive way, with concrete, cement or other materials.
- 9 In such cases, as shown in Fig.s 6 and 7, the lower edge is
- 10 fastened by anchors set in recesses 22 formed into the cement
- 11 to bury or partially bury eyebolts 24. The eyebolts 24 are
- 12 permanently screwed into the remaining portion of the cement.
- 13 Obviously this invention contemplates other methods of
- 14 anchoring the top and bottom of the curtain panels depending on
- 15 the particular application.
- In Fig. 9, the a ground anchor 110 is used to secure the
- 17 barrier to the earth. These anchors may vary in design to
- 18 provide the requisite holding power in different soils. The
- 19 designs include ground anchors typically used to secure
- 20 telephone pole guy wires to the ground. In Fig. 9, the anchor
- 21 110 has an eye 116 coupled to a clamp 112 similar to clamp 32.
- 22 Equally obvious is the fact that the sides of the panels
- 23 where appropriate can likewise be anchored. As shown in Fig.
- 24 5, side edges of mating panels may be provided with releasable

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fasteners 76. As shown, the fastener is in the form of a 1 zipper but other fasteners may be employed, such as hooks-and-2 eyes, grommets-and-turn posts, male-and-female snaps, 3 button-and-holes. The fastener 76 is protected by a fly 73 4 attached along the length of the fastener to one panel. 5 fly has a cohesive closure, such as Velcro, with 6 cooperating tapes 78 disposed on the free edge of the fly and 7 on the other panel. As shown, the joining panel 63 has a 8 releasable fastener 76 along one edge and a fly 73 attached 9 parallel with the fastener. Side panel 64 has a cooperating 10 member of the fastener 76 attached along one edge and a closure 11 strip parallel to the fastener. 12 The panels may also be fabricated with a selvage or hem or 13 can utilize a reinforcing tape such as "Polytape" that is made 14 from a polypropylene material. The selvage or tape may include 15 commercially available grommets or rings to accept the tie-down 16 17 hardware. The attachment ring 30 carries a self-locking clamp 32 adapted to fit the eyebolt 24 to tie down the curtain. 18 7 clamp 32 captures a rod 38 and clamps to the eyebolt 19 In the Fig. 8 embodiment the clamp 32 is fitted to a 20 24. 21 sturdy rod 38 running the length of the bottom edge of the

barrier that is secured in the hem formed by folding the

material of the curtain as shown. In Fig. 8 the end cap 40

- 1 can serve as a glide in a track if end tracks (not shown) are
- 2 desired for raising and lowering the barrier. An automatic
- 3 deployment system could require such end tracks. The same
- 4 reference numerals depict like parts in all the Figs.
- 5 Commercially available grommets or attached rings 30 may be
- 6 utilized to hold the clamp 32. In this manner the curtain is
- 7 anchored via the clamp 32 and eyebolt 24. Rod 38 may include
- 8 an end cap 40 mounted on the end thereof to prevent the rod
- 9 from falling out of the loop of the curtain.
- 10 One method of rolling up the curtain in order to move it
- out of the way when not in use requires a pull cord (not shown)
- 12 that is looped around the end of the rod 38. The free end
- 13 freely hangs and allows the operator to pull or release it to
- 14 roll up or let down the curtain as required. Ideally the
- 15 deployed curtain should only be sufficiently taunt to take out
- 16 slack. If during the installation slack is left this should be
- 17 allowed for in calculating the said minimum spacing.
- 18 The edges at the top and bottom of each panel of the
- 19 curtain are folded over one or two times, forming a hem, to
- 20 assure the structural integrity of the panels. The side edges
- 21 of the curtains may be suitably attached to the siding of the
- 22 building (not shown) in which the material is wrapped around a
- 23 batten , such as batten 70, which is in turn fastened to the
- 24 wall with appropriate screws.

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Alternative end fasterings are shown in Figs. 10 and 11 wherein the ends are overlapped and releasably secured one to the other. 10, the hemmed edge of side panel 62 is In Fig. connected to joining panel 63 using two parallel strips 98, 99 of cohesive releasable fastener material on each panel. joining panel 63 is releasably connected to side panel 64, as shown in Fig. 11, through the hemmed edges which have reinforcing tapes 95 and 96. A plurality of loops 94 are fixed along the length of the edges with each loop threaded through a ring 90. As shown, the loops 94 on panel 63 are connected to releasable clamps 92. The clamps 92 cooperate with a double The double ended rings 90 are attached to the ended ring 90. To close the air gap at the extreme edges loops on panel 64. of the panels, a cohesive fastener 99, such as Velcro, is attached to both panels. The reinforcing tapes and the loops

17 What is shown by this invention is a simple, adaptable, transparent, economical, and aesthetically pleasing device that 18 is suitable to protect the building, doors and windows from the 19 forces of winds occasioned by hurricanes and the debris carried 20 21 by the winds. The textile barrier can either be removed and 22 stored in a very simple manner without requiring a lot of space or could remain installed and either rolled, swung or slid out 23 24 of the way.

may be of the same material as the barrier.

L	Although this invention has been shown and described with
2	respect to detailed embodiments thereof, it will be appreciated
3	and understood by those skilled in the art that various changes
ł	in form and detail thereof may be made without departing from
5	the spirit and scope of the claimed invention.